X-733-67-577

NASA TM X- 63289

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PLACE EXPERIMENT DESCRIPTION

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NOVEMBER 1967

GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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CONTENTS

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1. SUMMARY

The experiment proposed herein is based on a study performed in the Systems Division of the Goddard Space Flight Center and on the system concept described in "Position Location and Aircraft Communication Equipment (PLACE)," GSFC document X-731-67-159, April 1967. This study, was specifically directed toward an investigation of the dual aspects of communications and navigation as they relate to the existing and projected air traffic control requirements. The primary value of this preliminary study is that it points out that, from the engineering point of view, adequate technology already exists to meet the presently envisioned operational requirements of the mid 1970's. Of course, additional study and considerable experimentation is required to develop an economically justifiable and operationally tractable system.

The following proposal is based on utilizing the ATS-F satellite. An L-band repeater and an associated antenna will be required aboard the ATS-F spacecraft. The existing Rosman and Mojave ATS ground stations must be outfitted with appropriate L-band feeds, receivers and transmitters. The Rosman station will be the primary experimental facility in conjunction with the signal processing, computing, and operational control equipments at GSFC. The primary function of the Mojave station will be to serve as a receiving and transmitting terminal for voice, digital data and signal simulation testing of multiple-access characteristics of the satellite repeater.

The existing OPLE ground station will be modified and incorporated into the GSFC experimental facility to permit investigation of continuous and time-shared aircraft position location and tracking using both the now operational Omega network and independent VLF ground transmitters. The same basic OPLE equipments will perform satellite-to-aircraft range measurements, while the coherent frequency translation features of the satellite repeater will permit aircraft-to-satellite relative velocity measurements and ionospheric disturbance measurements. The relative velocity measurements will provide the basis for a separate navigation experimental investigation aimed at evaluating the ability to provide ground surveillance and updating of on-board aircraft inertial navigation equipments.

For the most part, fixed ground based equipments at GSFC, Rosman and Mojave will be used to simulate aircraft flight conditions. However, operating validation will be provided by actual aircraft flights utilizing an existing Apollo support aircraft and an FAA aircraft. Cooperative experimentation by other

agencies and organizations will be invited to broaden the base of the actual flight experimentation as far as practicable.

As a result of required developments, advances are expected in aeronautical L-band satellite and aircraft communication equipments. An important consequence of this experiment is that facilities will be developed that will provide a basis for a follow-on range-range navigation experiment by equipping the ATS-G satellite with a similar repeater.

2. INTRODUCTION

Meaningful and generally acceptable predictions of future global, or even regional, air-traffic density are very difficult to make. As a result, much disagreement exists between various countries and operating agencies concerning the operational requirements of air-traffic control systems and equipments. The continual increase in the number of flights over the North Atlantic region has fostered much concern, and many competent studies have been performed to determine the potential seriousness of the problem and to devise timely solutions.

At this point, there is general agreement on at least two points. With regard to the North Atlantic region, the air-traffic will continue to increase at least until the introduction of large transport and supersonic aircraft. Also, the maximum number of aircraft in flight at a time will increase to more than one hundred, but should not exceed two hundred through-out the 1970's.

Limitations of the present facilities available to flights over the North Atlantic are such that the most conservative estimates reveal them to be inadequate throughout this time period. It is obvious that communications will have to be improved, but accomplishment of this alone will not permit reductions in spatial separations between aircraft.

Among the possibilities for meeting future requirements, the use of satellites holds the most promise. Voice communication with aircraft in flight has already been demonstrated with the ATS-1 satellite. Satellite range and range-rate tracking system performances indicate that a multiple satellite position location system can provide adequate accuracies. The OPLE system has demonstrated that the ground based Omega navigational signals can be relayed by satellite to a central location. Digital data relay through satellites is common place.

Based on the GSFC study, an integrated communication and position location satellite system concept was developed. While this proposal is designed to

demonstrate and evaluate certain critical technologies essential to this concept, it will also provide a basis for comparison and a facility for testing other systems and future developments.

There are two primary objectives of this experiment. The first of these is to prove the feasibility of two-way communications between ground terminals and aircraft. Specific goals are:

- The use of a synchronous satellite for relaying all communications.
- The use of the aeronautical L-band for duplex satellite-to-aircraft links.
- The use of both voice and digital communication.
- The use of multiple access through a satellite for both aircraft-to-ground and ground-to-aircraft links.

The second objective is to investigate the feasibility and to evaluate the absolute and relative accuracies of three position location techniques utilizing a single satellite. Each of these techniques relay various signals from the aircraft via the satellite to the control center for data processing and position determination. The first two techniques listed below make use of signals received by the aircraft directly from ground based transmitters. The third technique makes use of only satellite signals and data derived from on-board aircraft equipments. These techniques are:

- Hyperbolic lines of position, using the now operational U.S. Navy Omega Navigational System signals.
- Circular lines of position, using ranging signals from the satellite and one or more Omega stations.
- Combination of circular lines of position, using ranging signals from the satellite, and angle determination, using relative velocity (doppler) with respect to the satellite along with absolute velocity measurements made on board the aircraft (designated as SIND system by GSFC).

3. EXPERIMENT DESCRIPTION

3.1 General Considerations

One objective of this experiment is to demonstrate multiple access techniques capable of supporting up to 200 aircraft simultaneously. This capability would

require at least ten ground-to-aircraft communication channels. With the ATS-F satellite power limitations and ten ground-to-aircraft communication channels, an aircraft antenna gain of approximately 25 db would be required. At L-band this corresponds to an aperture of about five (5) feet. Experimentally, this is not an insurmountable obstacle; in fact, NASA already has available five aircraft equipped with seven (7) foot diameter antennas for which L-band feeds are available. These aircraft are modified C-135's (EC-135N) designated as Apollo/Range Instrumented Aircraft (A/RIA).

Operationally, an aircraft antenna with 25 db gain compatible with existing and future air-frames is impractical. Also, the satellite antenna gain is limited by the earth disc coverage required. Therefore, evolution of an operational global air traffic control network of large capacity will depend on satellites with power sources comparable to some of the military communication satellites presently under development.

Clearly, an experiment requiring a large number of aircraft equipped with high gain antennas could not be justified. For this reason, the proposed experiment has two separate and distinct aspects. In the first part of the experiment, no actual aircraft need be involved. Ground-based simulation equipments will be fabricated to investigate power control, random access and queuing techniques and to determine loading factors, intermodulation characteristics and other properties related to the system capacity and reliability. During these tests, the full capacities of the PLACE system concept will be exercised utilizing a minimum amount of facilities. This will evaluate most of the features essential to a 200 aircraft capability.

In the second part of the experiment, one of the A/RIA aircraft will be utilized on an "as available basis" to demonstrate operation under various flight conditions and to verify results obtained under simulated conditions. However, the scheduling demands on the A/RIA aircraft could limit their participation in this experiment. Also, it would be desirable to provide for cooperative experimentation with other aircraft having antennas with lower gain. Therefore, a second mode of operation employing only one or two voice channels from the ground to the aircraft will be provided. In this way, a 15 db gain antenna (equivalent aperture of 1.5 feet) would be sufficient to permit properly equipped aircraft to participate simultaneously and to communicate on a time-shared basis.

3.2 Implementation

In consideration of the objectives, certain hardware must be developed. The following minimal implementation is proposed.

3.2.1 Ground Station

An important feature of an air-traffic control satellite system is the ability for more than one ground station to have access to the satellite at a time and provision for this is a part of the PLACE system. Simultaneous operation in a frequency division multiple access (FDMA) satellite system has been achieved with two ground stations, but it has not been adequately demonstrated with three or more ground stations. It is proposed that three ground stations be employed in the experiment so that this feature can be fully evaluated and demonstrated. The primary ground station will make use of the existing eighty-five foot antenna installation at Rosman, N.C. This station will have both communication and position location capability. The second ground station will make use of the existing forty foot antenna installation at Mojave, California. This station will be equipped only to simulate the operation of an alternate PLACE control center. In this capacity it will have limited communication capabilities and will not have position location capabilities. The third station will require a five foot diameter antenna and will serve as a ground station simulator. In this capacity, it will participate in the multiple access tests only, and as such, will primarily function as an emitter. For the most part it will be outfitted with off-the-shelf equipments in a minimal configuration. The location of this station is not particularly important although it should probably be located as remotely from both Rosman and Mojave and as far North as practical. Potential locations for this station include GSFC, Greenbelt, Maryland; NAFEC, Atlantic City, New Jersey; or E.R.C., Boston, Mass.

3.2.2 Satellite

It will be necessary to equip the ATS-F satellite with a modulating duplex repeater feeding an equivalent 3.5 ft. aperture earth pointing antenna. Discussions with cognizant project personnel indicate that such an antenna can be mounted on the Earth Viewing Module (EVM) without compromising the performance of the large antenna. One repeater channel will receive in the 5 to 5.25 GHz band and will transmit with 40 watts of output power in the 1.54 to 1.66 GHz band. The other repeater channel will receive in the 1.54 to 1.66 GHz band and will transmit with less than 4 watts of power in the 4.2 to 4.4 GHz band. Both repeaters will maintain phase coherence with the 5 to 5.25 GHz carrier received from the Primary Control Ground Station.

3.2.3 Aircraft Transceiver

One breadboard and three engineering models of an aircraft transceiver will be fabricated. The breadboard model will be used to aid in the integration and check-out phase of the Primary Control Center equipment development at the contractor's facility. At this time it will be incorporated into the control

center system and will remain with it throughout the experiment for test and calibration purposes. One of the three engineering models will be placed aboard NASA aircraft for use during the actual aircraft flight test portion of the experiment. The Mojave station and the ground station simulator will each be equipped with an engineering model aircraft transceiver. These transceivers can provide simulated air-traffic and will also serve as fixed reference points for calibrating the position location equipments. These transceivers are essential to the performance of a thorough and self-sufficient PLACE experiment.

4. EQUIPMENT DESCRIPTIONS

Equipment configurations necessary to meet the previously stated experiment objectives for the satellite, the aircraft transceiver, and each of the ground stations are described below.

4.1 Satellite Equipment

The satellite equipments of interest are the antenna and the duplex repeater. The particular requirements for each of these items are outlined in the following paragraphs.

4.1.1 Satellite Antenna

The satellite antenna required for this experiment is an equivalent 3.5 foot aperture dish which is common to all PLACE links through the satellite. At 1.5 GHz it will provide 22 db on-axis gain with an equivalent conical 3 db beamwidth of 14 degrees. This is less than full earth disc coverage, but sufficient for experimental purposes. Proper location of antenna feeds will be required to provide coverage in the region of interest. At 5 GHz this antenna will provide 32 db of gain on-axis with an equivalent conical 3 db beamwidth of 4 degrees. This will also require proper location of the feed so that this beam will cover the ground stations. Consideration will be given to employing two separate antenna feeds for the 5 GHz links (to and from the ground stations) creating two beams. One beam could be pointed toward the United States and the other beam could be pointed toward western Europe.

4.1.2 Satellite Repeaters

In PLACE two links must be relayed through the satellite. The ground to aircraft (GA) and aircraft to ground (AG) repeaters required to perform this function are discussed in the following two sections. Figure 4-1 is a simplified block diagram of this dual repeater and shows the single frequency synthesizer which is common to both repeaters.

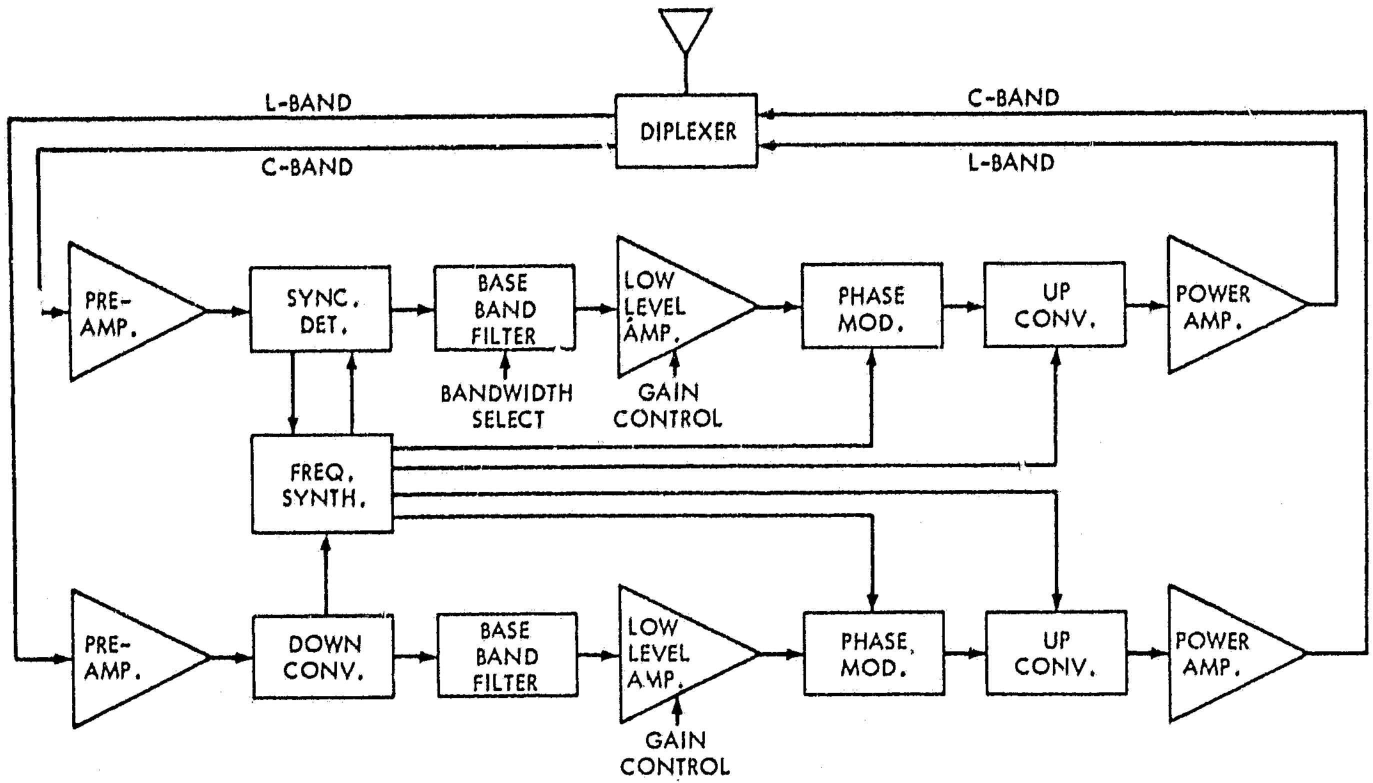


Figure 4-1. Simplified Block Diagram of Duplex Satellite Repeater

4.1.2.1 Satellite Repeater-Ground to Aircraft

The Ground-to-Aircraft (GA) repeater will be required to simultaneously receive transmissions from more than one ground station. The total received signal from all the ground stations can be recovered in the satellite through synchronous detection since the satellite frequency synthesizer is phase locked to the Primary Control Center carrier component. The resulting composite signal (shown in Figure 4-2) will then be used to directly phase modulate a subcarrier, derived from the frequency synthesizer, which is then translated to the carrier frequency under control of the same frequency synthesizer. The signals

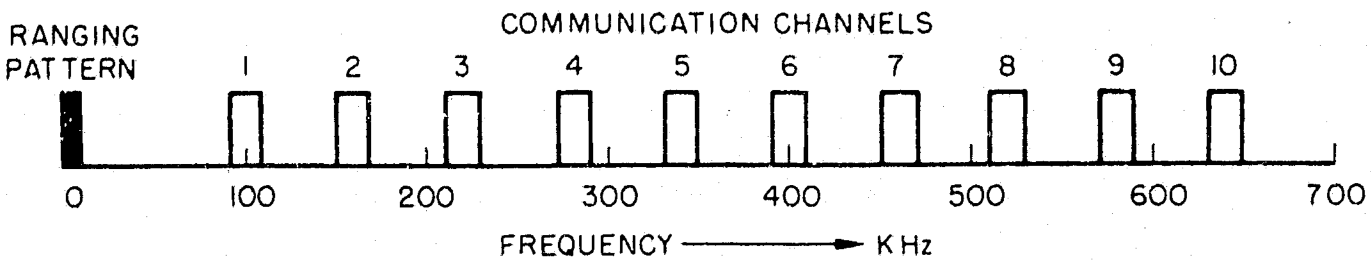


Figure 4-2. Composite Spectral Diagram at the Satellite

from the ground stations will be received in the 5 to 5.25 GHz band and be relayed to the aircraft in the 1.54 to 1.66 GHz band.

The constant amplitude signal transmitted by the GA repeater will be angle-modulated with an rms phase deviation of one radian. This will be accomplished by amplitude control of the composite signal on the satellite in conjunction with active control at the ground stations of the individual transmitter powers. Since the satellite repeater output is a phase modulated signal, amplitude linearity requirements on the transmitter power amplifiers are minimized and the efficiency of the satellite transmitter is maximized.

Two different selections of received and transmitted signal bandwidths will be provided in the GA repeater to achieve the experiment objectives. Proposed satellite bandwidth selections are given in Table 1.

Table 1

Bandwidths	Mode 1 10 voice channels	Mode 2 2 voice channels
Received Bandwidth	700 KHz	190 KHz
Transmitted Bandwidth	2.8 MHz	0.76 MHz

Mode 1 will be used for all engineering and evaluation tests involving aircraft simulation, while Mode 2 will be used primarily for aircraft in flight. The total satellite output power will be independent of the selected Mode, thereby allowing an increase in the signal power per channel for Mode 2. The GA repeater should provide 40 watts of output power, for an ERP of 37 dbw in the antenna beam axis.

4.1.2.2 Satellite Repeater-Aircraft to Ground

The aircraft-to-ground (AG) repeater will provide the multiple access capability similar to that provided in the GA repeater with the same technical approach. The composite signal received from all the cooperating aircraft will be down converted in the satellite by use of signals from the same frequency synthesizer that is used in the GA repeater. As stated previously, this frequency synthesizer's phase locked to the carrier component of the Primary Control Center's transmissions, thereby allowing coherence throughout the system. The composite signal received from all the aircraft is directly angle modulated

(with an rms phase deviation of one radian) onto a subcarrier which is then translated to the output carrier frequency under control of the frequency synthesizer. Due to the large number of aircraft channels being simultaneously received it is not expected that individual output power control on each aircraft will be necessary to prevent large variations in the statistics of the composite signal. It will be necessary to provide some control over the signal into the phase modulator on the satellite to assure a nearly constant rms phase deviation. This control could be provided by an AGC or by satellite commands sent from the Primary Control Center. The signals from the aircraft will be received in the 1.54 to 1.66 GHz band and be relayed to the ground stations in the 4.2 to 4.4 GHz band.

4.2 Aircraft Transceiver

The aircraft transceiver requirements and operation are discussed in the following section. The principal areas of interest are the communications and the range tone processing for position location.

The aircraft transceiver is shown in a functional block form in Figure 4-3. In a sense, it will operate as a coherent repeater in a similar fashion to the satellite GA repeater. That is, it will receive the 1.5 GHz signal from the satellite, phase lock to the carrier component, and synchronize a frequency synthesizer. The frequency synthesizer will generate the aircraft transmitter carrier in the 1.5 GHz region. This carrier is phase coherent with the carrier received from the satellite, but is offset from the received carrier in frequency (by an amount determined by the transmit channel selector and the doppler correction unit). In terms of the carrier component then, the aircraft transceiver is a coherent transponder.

The transceiver phase-locked loop will demodulate the signal received from the satellite to produce the satellite ranging tones, the timing/control signal, and the subcarrier voice and data channels. By simple filtering, the signal will be separated into its components. A simplified diagram of the receiver portion of the aircraft transceiver is shown in Figure 4-4 which also summarizes the important design parameters.

The timing/control signal is a binary data stream which is fed to the timing/control unit. This unit contains a timing clock generator which is synchronized by the timing/control signal and controls the range tone commutator. The range tone commutator is also fed the range-tone pattern from the phase-locked detector. All range tones are time commutated, under control of the timing signal, and then frequency translated, under control of the frequency synthesizer. The voice and data subcarriers are fed to a demultiplexer where the received data and voice channels are separated and demodulated.

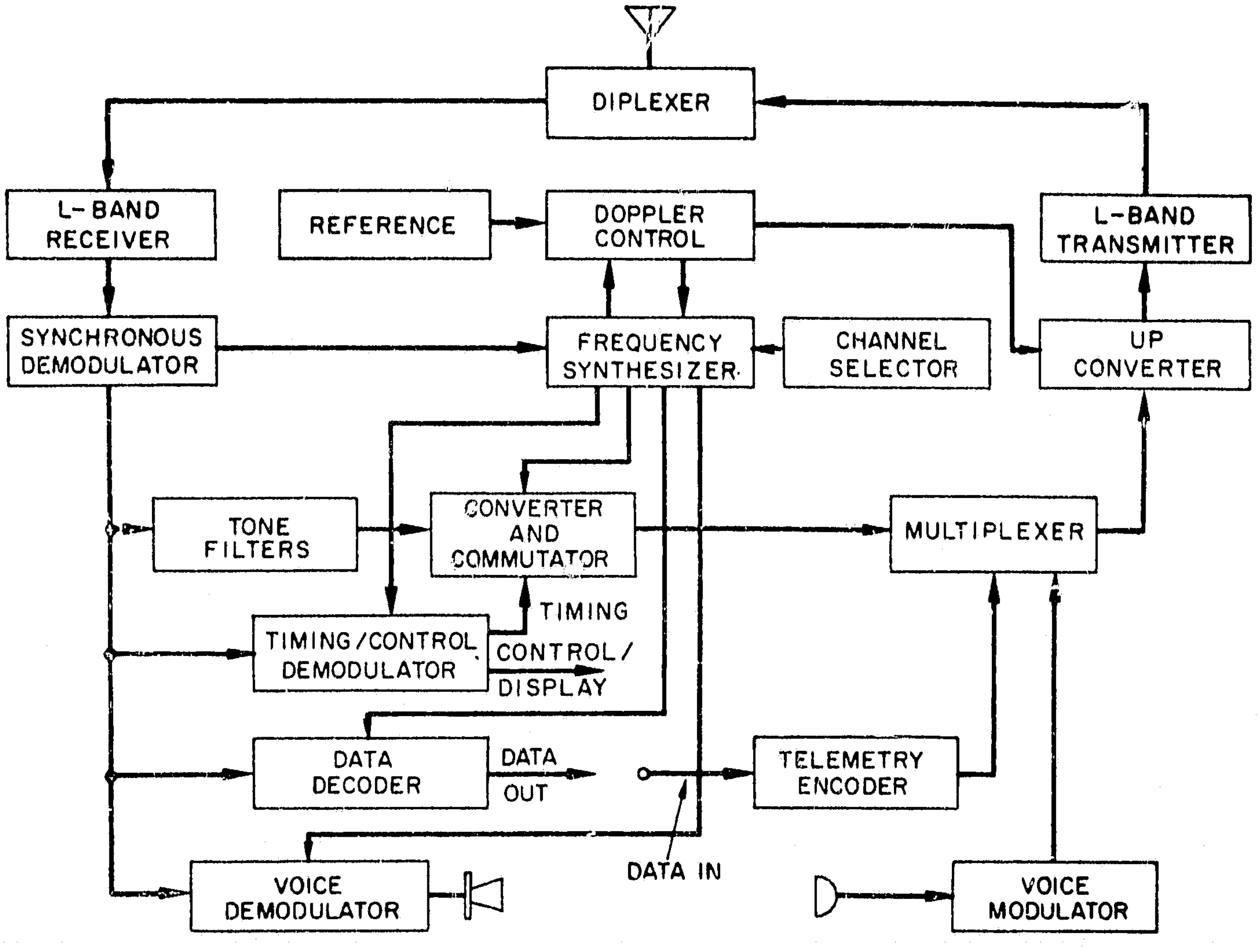


Figure 4-3. Functional Block Diagram of Aircraft Transceiver

The processed range-tone pattern and the aircraft derived voice and data information are combined by frequency division multiplexing prior to transmission as shown in Figure 4-5a. This combined signal is modulated onto the transmitter carrier by a single sideband technique. The carrier component is used for both doppler tracking and signal recovery. Each aircraft is assigned a separate transmission channel which is offset in frequency from every other aircraft as determined by the transmit channel selector. Thus a "stacking" of aircraft transmitter signals will be accomplished as shown in Figure 4-5b. The transceiver power output will be 50 watts.

The frequency control section of the transceiver has already been discussed; so that, the portions of primary concern at this point are those having to do with the range tone processing.

A functional diagram showing more detail of the tone processing of the aircraft transceiver is shown in Figure 4-6. There are three distinct tone paths

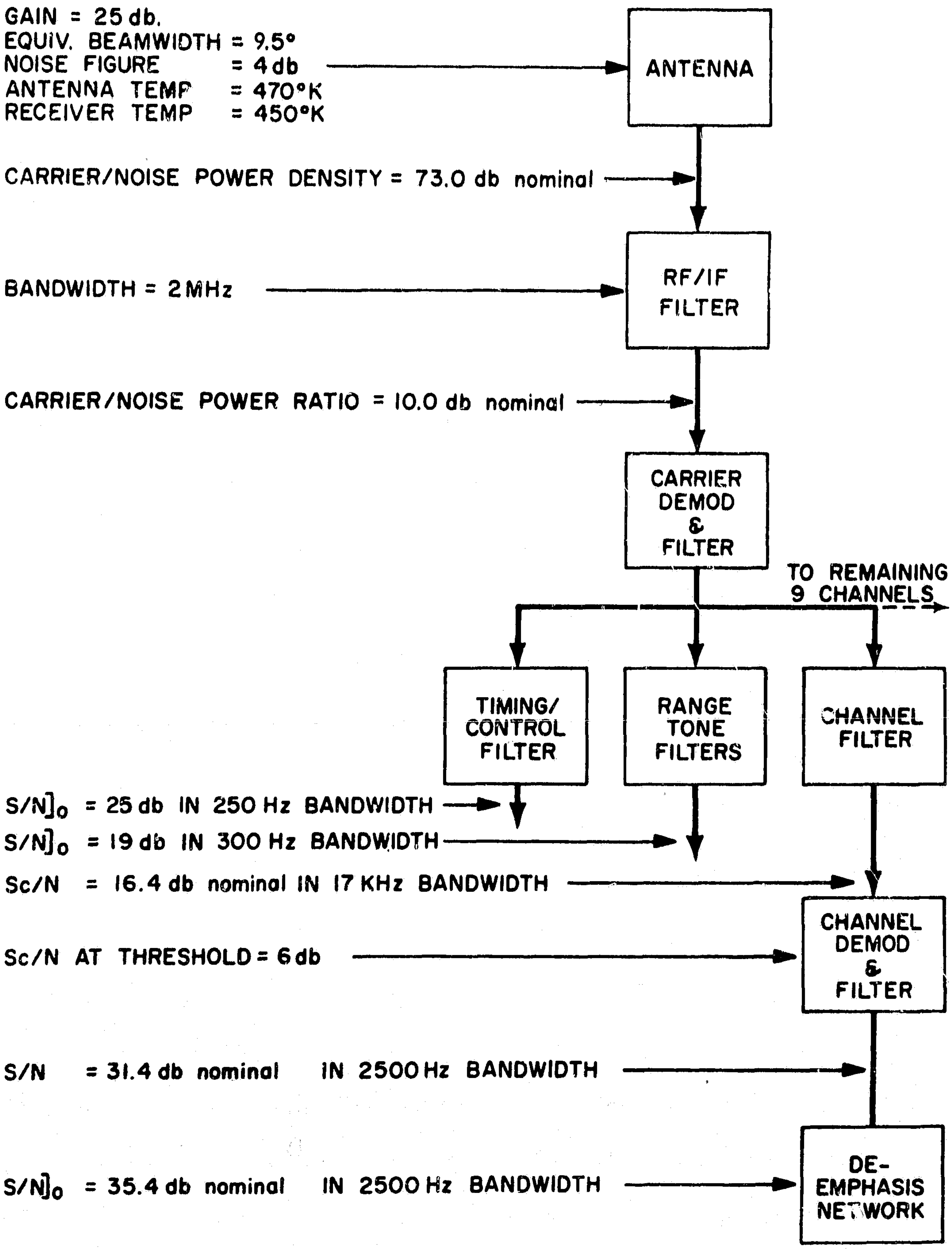


Figure 4-4. Example of Aircraft Receiver Characteristics

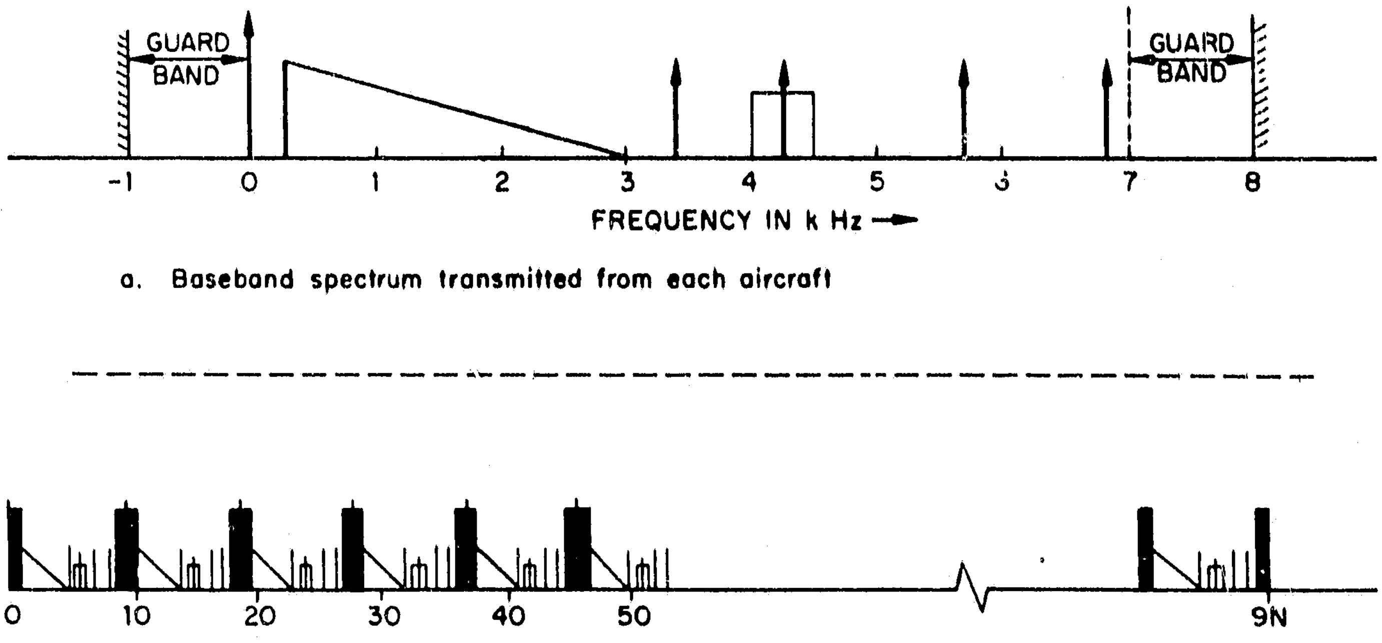


Figure 4-5. Aircraft-to-Satellite Spectral Diagram

corresponding to the three possible modes of operation. First, the tones received from the satellite, by the L-band receiver, are separated out by the 3 to 7 KHz bandpass filter and then transmitted to the satellite. This operation permits the measurement of the ground-to-satellite-to-aircraft two way range.

A second path exists, with the VLF receiver serving as the source of tones. Figure 4-6 has been drawn so that in this mode of operation the transceiver will be compatible with Omega, the U.S. Navy's VLF Navigation System. If the output of the 10.2 KHz filter is connected through the commutator to the summer in Figure 4-6, then the output of the VLF receiver will be relayed to the control center. In this mode, the position of the aircraft can be determined using only the inverse hyperbolic geometry of Omega.

If the VLF transmission are to be used in the range mode, a third signal path has been provided. The output of the 10.2 KHz filter from the L-band receiver is time commutated with the output of the VLF receiver. If Omega stations are being used, this tone will be inserted during time intervals when the four least useful Omega transmitters are radiating. The purpose of this tone is to provide an absolute reference for the VLF tones so that range as well as range-differences can be measured.

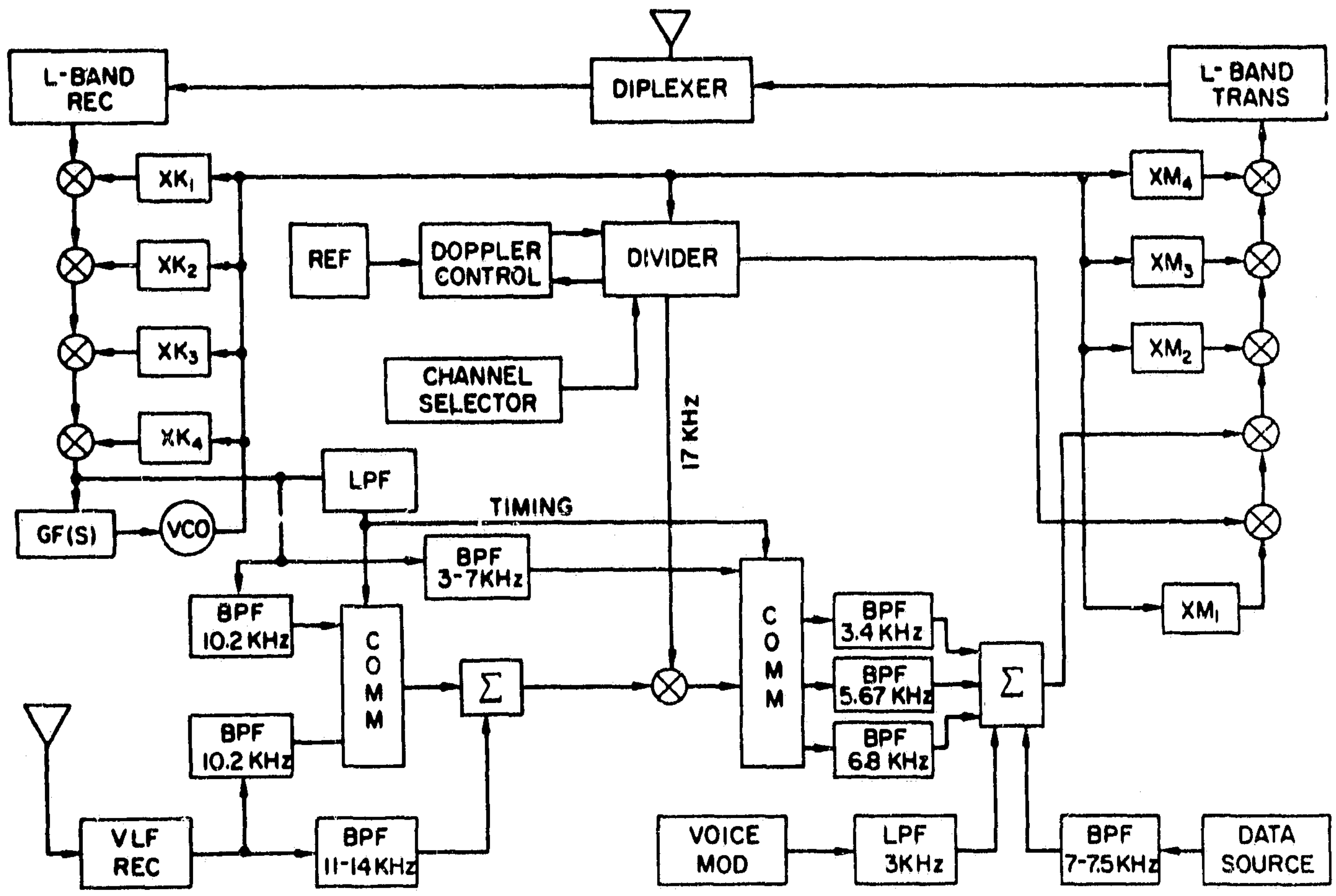


Figure 4-6. Functional Diagram of Aircraft Transceiver

Four aircraft transceivers are required and will be placed at Rosman, North Carolina; Mojave, California; in a ground station simulation unit; and onboard a participating NASA aircraft.

4.3 Ground Stations

The Rosman Station is of major importance since it operates in conjunction with the experimental position location facility. The Mojave Station operates as a communication terminal only and performs no position location functions. A ground station simulator will be utilized in addition to Rosman and Mojave. Each of the ground facilities will be equipped with an aircraft transceiver for simulation of aircraft during the communications tests and the transceivers will share the ground station antennas.

4.3.1 Rosman Ground Station

The Rosman station will have the ability to originate and receive voice and digital data; to originate, receive, and make measurements on range tones; to

perform position fixing computations to determine the location of cooperating aircraft; and to perform certain control functions as required. The Rosman station will transmit at its assigned carrier frequency in the 5.0 to 5.25 GHz band in accordance with available frequency assignments for this type of service. Referring to Figure 4-7, this carrier will be modulated by a baseband signal consisting of: 1) a timing/control (digital) signal; 2) a pattern of ranging tones; 3) a digital data or voice signal in one or more of the available voice channels. The timing/control signal will occupy a total bandwidth of about 500 Hz, while each of the ranging tones is at a single discrete frequency. The voice channels occupy approximately 17 KHz of bandwidth each and consist of nominal 3 KHz wide baseband signals frequency modulated onto carriers with an rms deviation ratio of 2:1. Each of the ground stations will transmit a similar frequency modulated voice signal on a carrier which is displaced from the Rosman Ground Station carrier.

The Rosman Station will utilize the 85 foot dish for both transmission and reception of the PLACE signals at both C and L band. This antenna will provide an on-axis gain of 60 db with a beamwidth of 0.17 degrees in the 5 GHz frequency

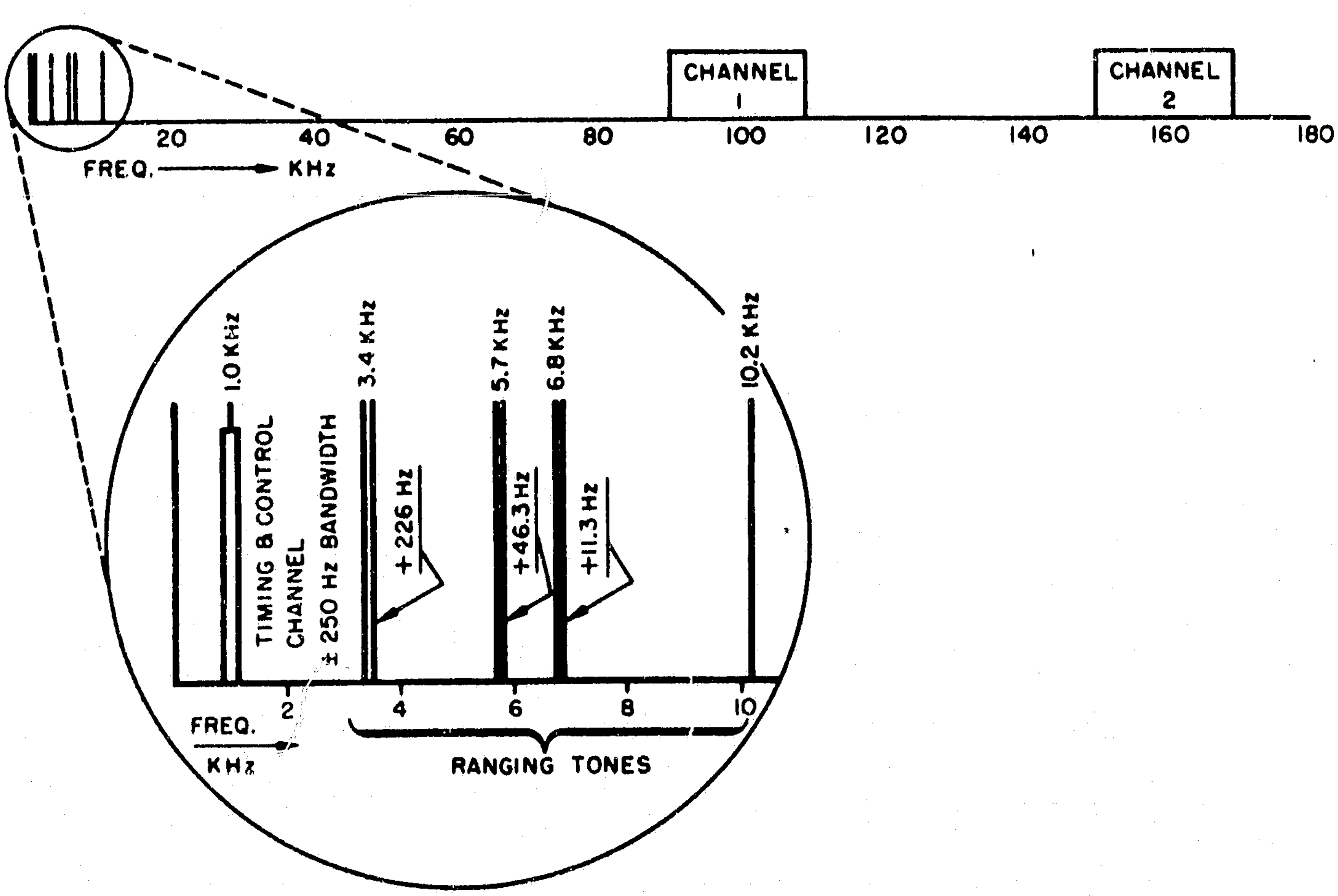


Figure 4-7. Primary Control Center Baseband Spectral Diagram

range. Each voice channel from the Rosman Station will require less than 0.5 watts of power into the antenna. A maximum of eight voice channels will be required of Rosman, resulting in less than four watts of output power. Less than 10 milliwatts of power will be required for the ranging pattern, and about the same will be needed for the timing/control signal. Since only four aircraft transceivers are planned, the Rosman station will perform the simulation of transmissions from the remaining aircraft by noise loading the satellite AG repeater. Thirty-five watts of additional radiated power will be required for this function.

The L-band receiver will allow the ground station to monitor the signals relayed to the aircraft from the satellite. Thus, power and frequency control of the ground station transmissions can be accomplished. Power monitoring is required to maintain the total phase deviation in the GA repeater at a nearly constant value regardless of the number of voice channels being used. Frequency control will be used to correct for ground station-to-satellite doppler. In addition to these control functions, the 1.5 GHz signal is used to perform range measurements between the satellite and the ground station. These measurements are a necessary part of the position location process. Figure 4-8 is a simplified block diagram of Rosman L and C band receivers. The various monitoring and control functions are indicated on this drawing.

The C-band Receiver completes the aircraft-to-ground link by recovering the aircraft signals with a phase-locked demodulator. The composite signal received from the satellite is separated by the channel selectors into separate aircraft channels. The individual channel is then separated into its three component parts for respective processing. Namely, the voice signal is separated out, and the ranging tones and digital telemetry data are fed to the phase measuring and digital decoding equipment and then to the data processor.

The data processor will perform the position fixing computations using the phase measurements on the ranging tones, the frequency measurements on the aircraft carrier, and portions of the digital data from the aircraft. The results of these computations will be the latitude-longitude coordinates, present velocity and direction of motion, and other factors pertinent to the location and status of the aircraft. The position location facility will locate and track only one aircraft in real time. Position location data for other aircraft will be recorded for off line processing. This will be sufficient for experimental purposes.

4.3.2 Mojave Ground Station

The only function of the Mojave Ground Station is the transmission and reception of voice and digital signals. It will transmit on an assigned carrier

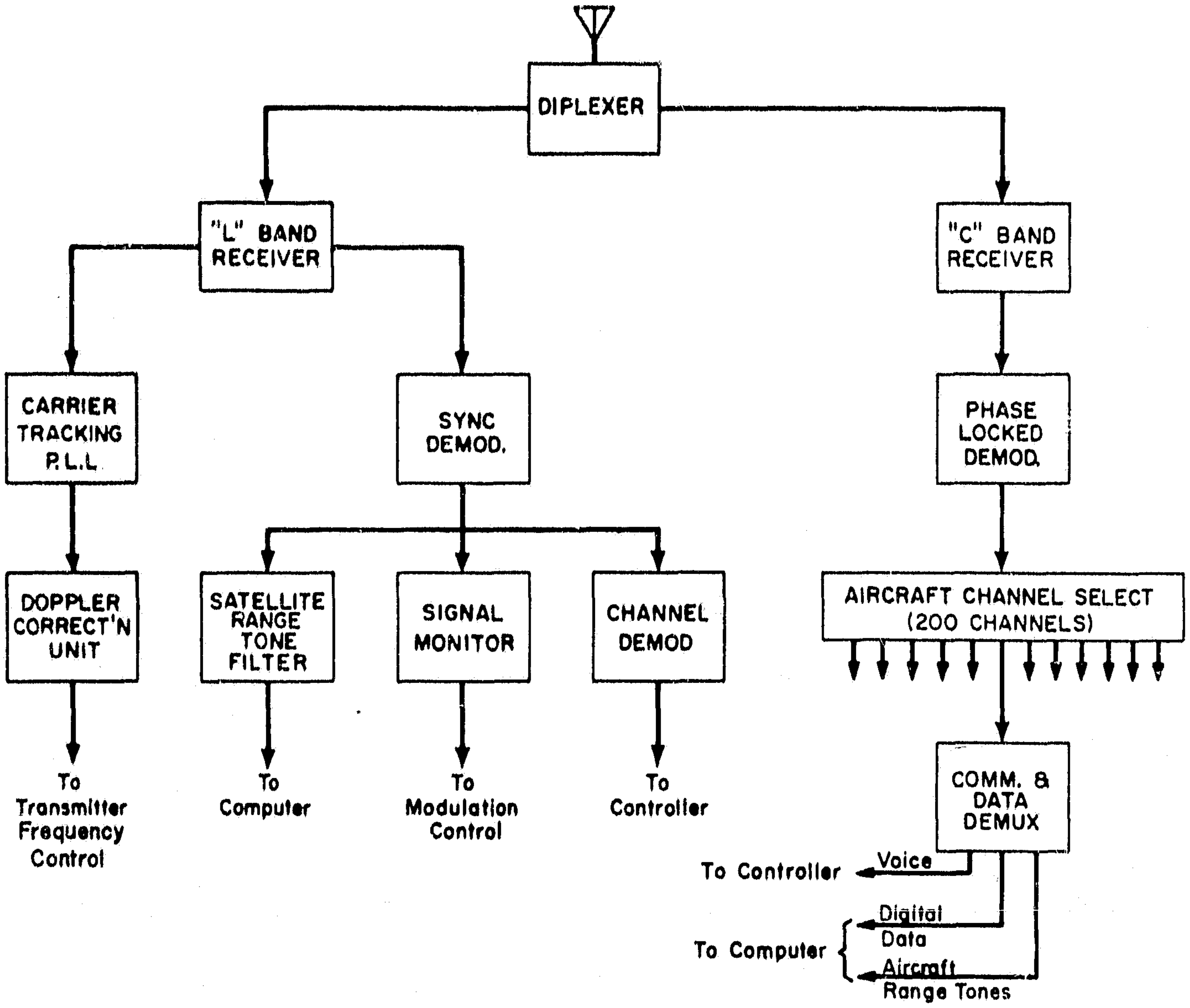


Figure 4-8. Simplified Block Diagram of Rosman Receivers

frequency in the 5.0 to 5.25 GHz range (as does the Rosman Ground Station). Mojave will differ from Rosman in that it will transmit only one voice signal in one of the voice channels.

With the 40 foot diameter Mojave antenna, the voice channel transmitter will transmit less than 2 watts in the voice channel which will maintain a received signal-to-noise ratio at the satellite that is commensurate with the Rosman transmissions. This smaller antenna aperture will still permit reception of the C-band signal although there will be little margin left in this link.

It will also be necessary for this ground station to monitor the L-band transmissions from the satellite to enable control of power and frequency

parameters. In all three ground stations it will be necessary to control the amplitude of ground station transmissions as received in the satellite, and to obtain the carrier reference from the Rosman Station. The Mojave L-band equipment will be similar to that of Rosman with the exception that measurement of the range to the satellite will not be made.

The Mojave C-band receiver will receive the total spectrum relayed from the aircraft via the satellite, and will demodulate and subdivide this signal in the same way as Rosman. Since Mojave will be limited to communication functions, no data processing equipment will be necessary.

4.3.3 Ground Simulation Unit

The function of the Ground Simulation Unit is to transmit a voice signal for use in multiple access tests. This unit will use a five (5) foot parabolic antenna for all links to and from the satellite. The reduced aperture will necessitate an increase in the radiated power to about 100 watts to provide the same margin that exists in the other two ground station-to-satellite links. The reduced antenna gain will also prohibit this unit from receiving the aircraft transmission relayed from the satellite to the ground stations. This unit will be equipped with an aircraft transceiver which will also utilize the five (5) foot antenna. The transceiver will permit power and frequency monitoring and control functions.

5. COOPERATING EXPERIMENTERS

The experiment description that has been presented has dealt primarily with the proposed NASA efforts. To obtain the full benefit from this effort, cooperation from private industry, other government agencies, and authorities outside the zone of the interior is highly desirable and should be encouraged.

The Federal Aviation Agency (FAA) has expressed a high degree of interest in this program and have stated an intention to participate as a cooperating experimenter. In this roll they plan to develop both an aircraft antenna and an aircraft transceiver suitable for one of the FAA aircraft and compatible with the PLACE system. The FAA has also advised NASA that they anticipate independent participation by members of the aircraft industry in the event that the opportunity is presented.

The selection of Mode 2 on the satellite, which has been discussed previously, will allow participation by cooperative experimenters with practicable aircraft antennas. This smaller bandwidth mode will support two voice channels to an inflight aircraft with an aircraft antenna gain on the order of 15 db. This

smaller value of aircraft antenna gain should be attainable in time to participate in the actual test flight phase of this experiment.

Although no information is presently available on possible cooperation from organizations outside the zone of the interior, it is expected that interest in such participation will arise at some future date. It is proposed that dual feeds be used for the 4.2 to 4.4 GHz and 5.0 to 5.25 GHz bands so as to form two beams, each beam covering both bands. This would allow much greater flexibility in the location that participating experimenters could use for ground stations. By positioning the satellite at 30° west longitude, the majority of Europe could be covered by an east-pointing beam and the eastern United States could be covered by a west-pointing beam (see Figure 5-1). If the satellite is positioned at 48° west longitude, the beams could illuminate western Europe and the majority of the United States (see Figure 5-2). A position of 120° west longitude would cover the central and eastern United States and Hawaii (see Figure 5-3). For coverage of Japan and the western United States, a satellite position of 150° west longitude could be used (see Figure 5-4). This dual beam configuration would allow demonstration of the intercontinental aspects of the PLACE air-traffic control system.

In the event a supersonic transport (SST) is suitably equipped by an independent experimenter, this aircraft could participate in the PLACE experiment with no modification to the presently proposed experiment configuration. The availability of an SST would allow continuous tracking of a high velocity aircraft. The PLACE equipment could also provide a continuous low data rate digital channel between this experimental aircraft and a central station, thereby yielding benefits to both the PLACE and SST programs.

The design of the PLACE system allows the use of a second earth orbiting satellite as a ranging source, provided proper tone processing is added to the aircraft transceiver. In the event that a second satellite becomes available it would be possible to conduct dual satellite navigation system tests with only minor modifications to the aircraft and ground station equipments. This is not a part of the present experiment, although if sufficient interest and monies become available there is no technical reason that an additional experiment of this type could not be accomplished.

6. MANAGEMENT

The Goddard Space Flight Center of the National Aeronautics and Space Administration will conduct the scientific investigation of the Position Location and Aircraft Communication Equipment Experiment (PLACE) and is producing the necessary equipments to demonstrate operational feasibility.

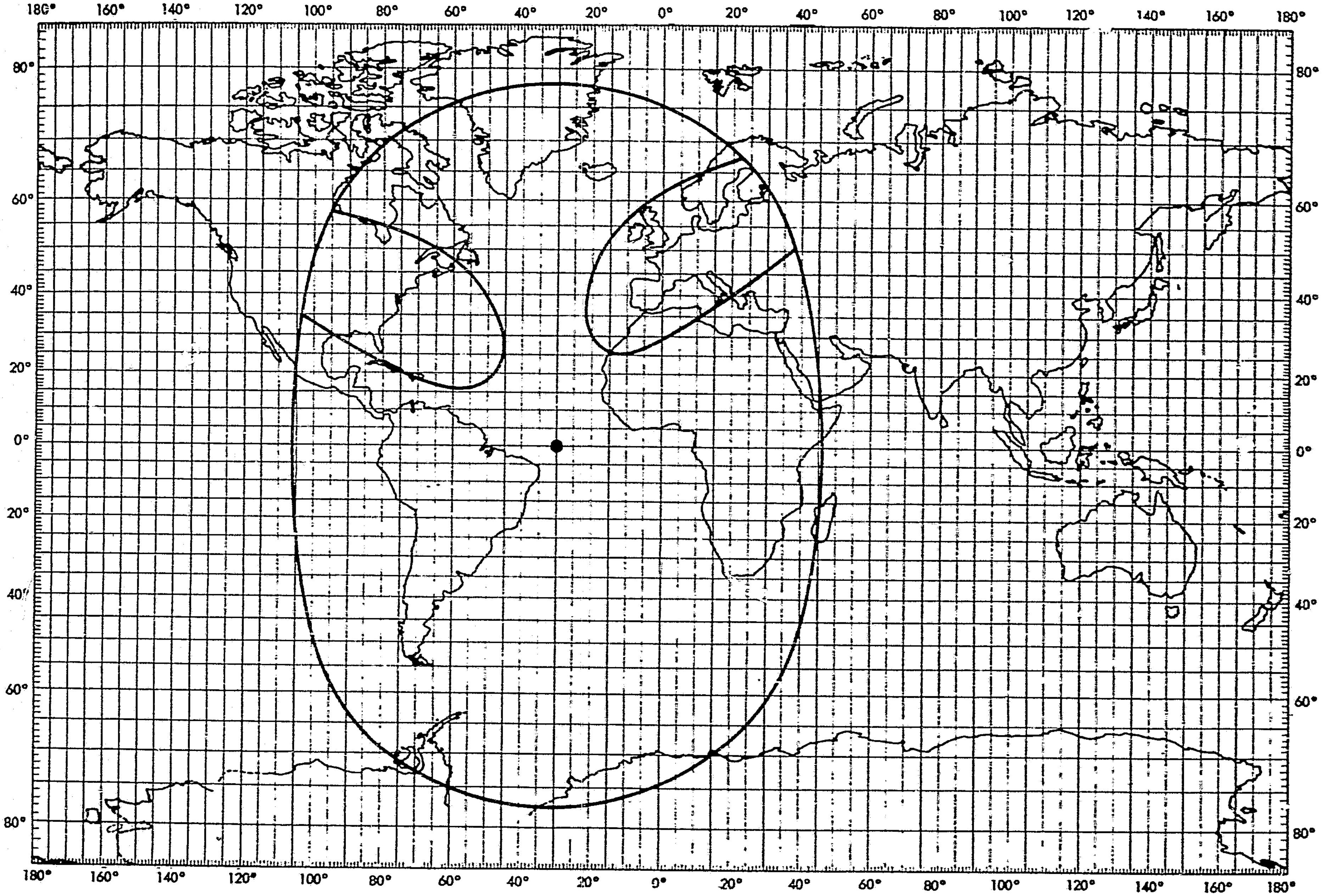


Figure 5-1. Coverage for Satellite at 30°W. Longitude

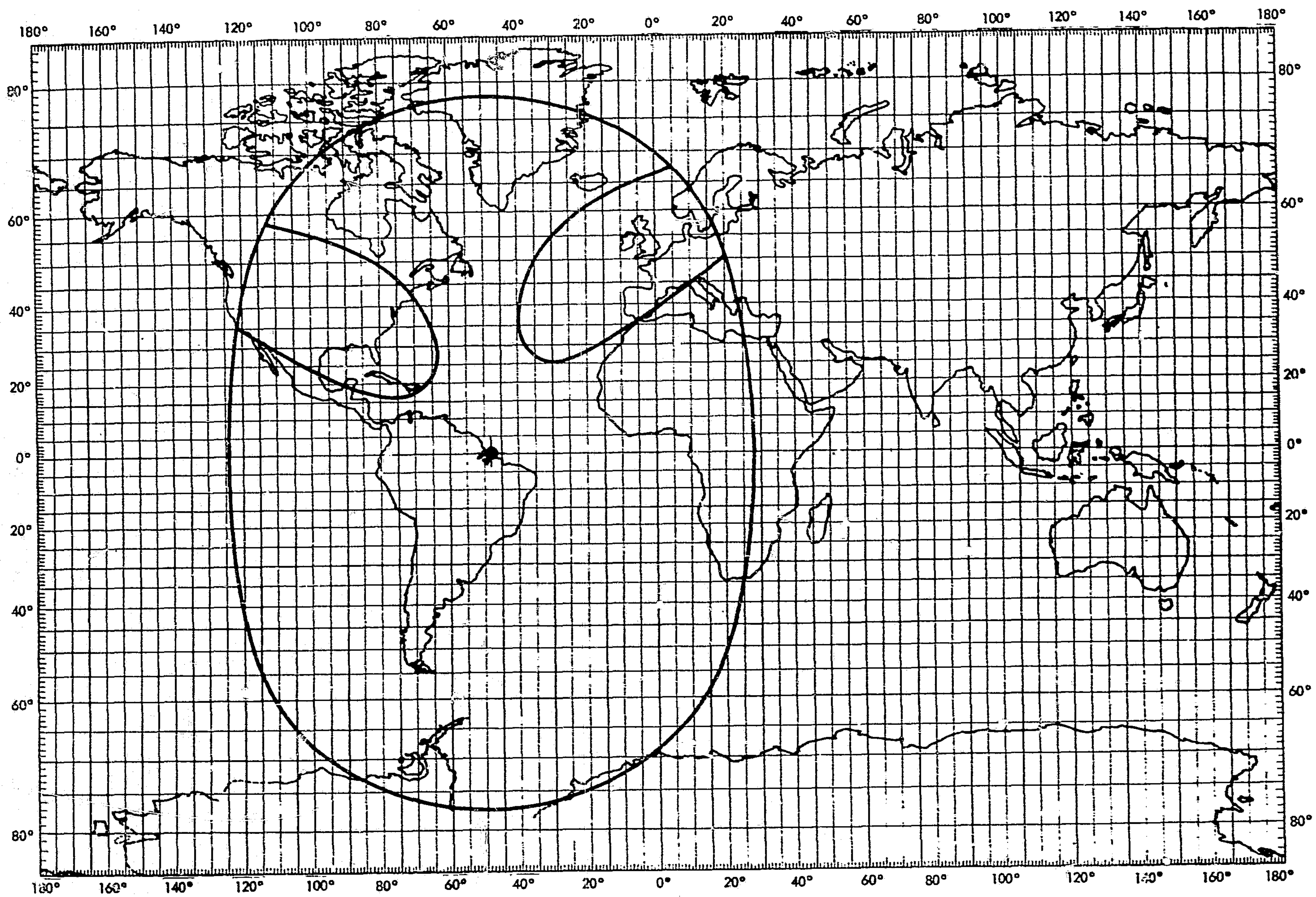


Figure 5-2. Coverage for Satellite at 48°W. Longitude

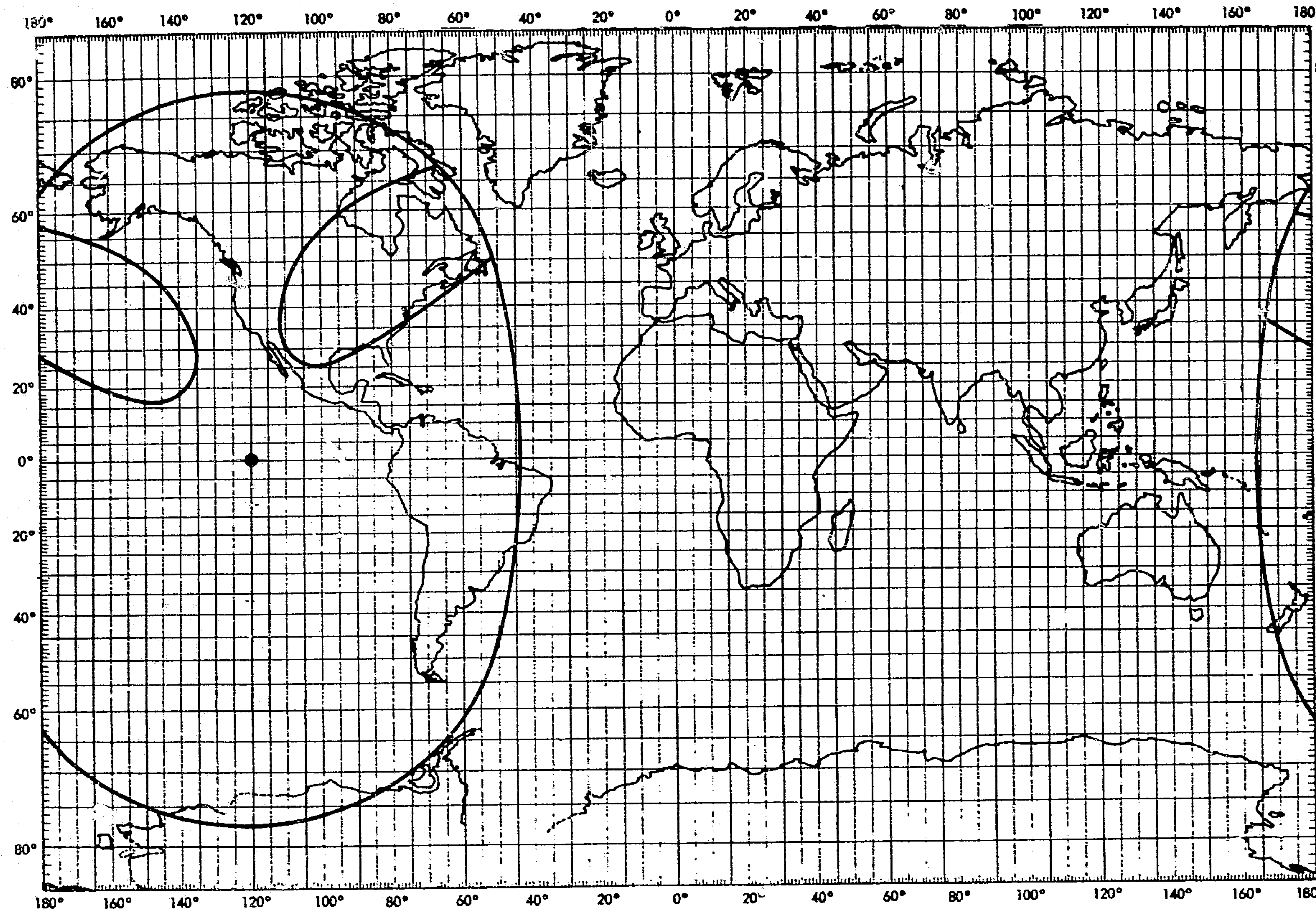


Figure 5-3. Coverage for Satellite at 120°W. Longitude

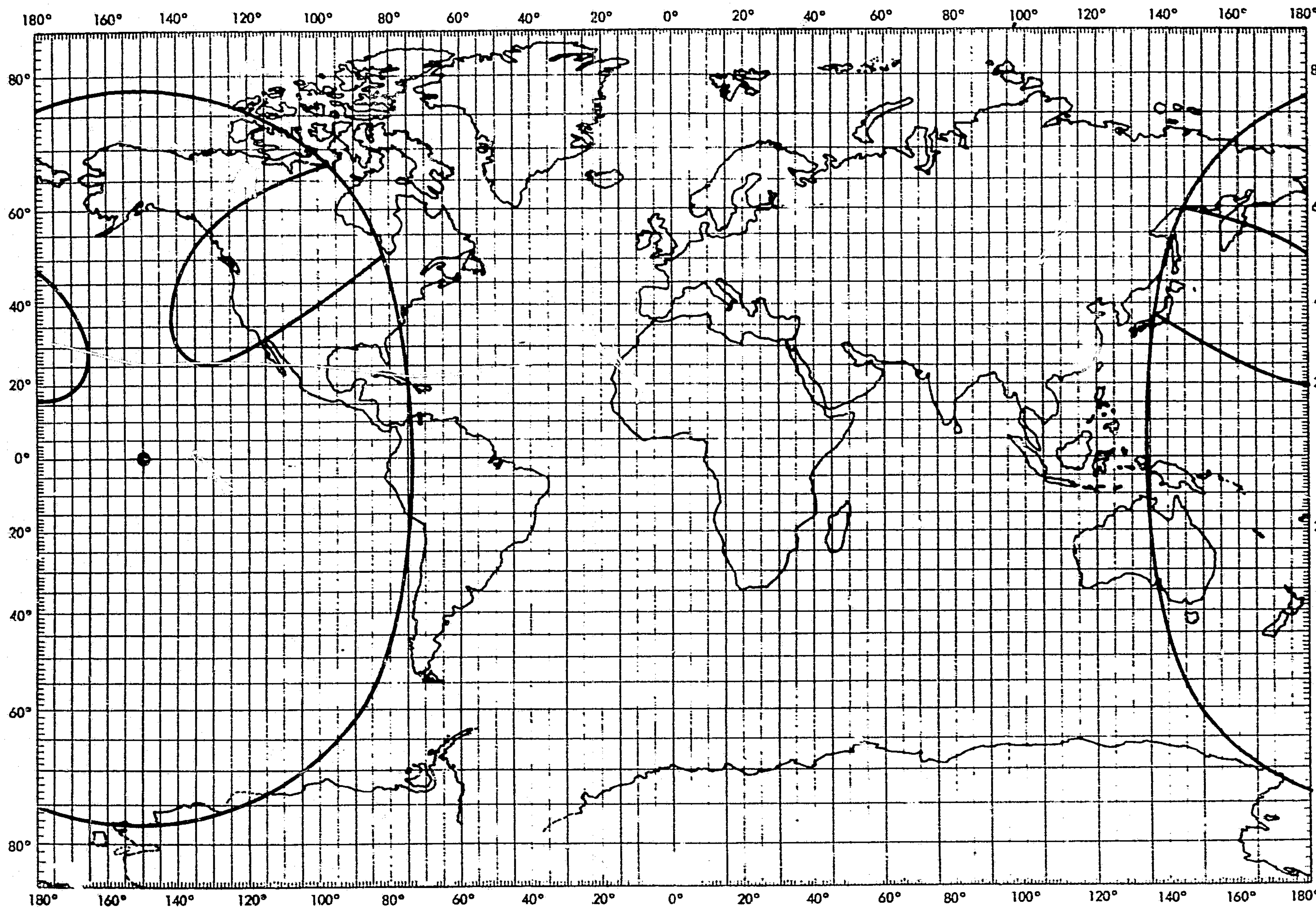


Figure 5-4. Coverage for Satellite at 150°W. Longitude

Responsibility for the investigation is assigned to the Data Collection Systems Section of the Communications Research Branch of the Systems Division, Goddard Space Flight Center. Mr. A. E. Jones is Chief of the Division, Mr. R. H. Pickard is Head of the Branch and Mr. W. I. Gould is Head of the Data Collection Systems Section.

Contractors are being utilized to develop and fabricate the various equipments necessary for the experiment. Administrative support is being provided through Dr. Michael J. Vaccaro, Assistant Director, Office of Administration.

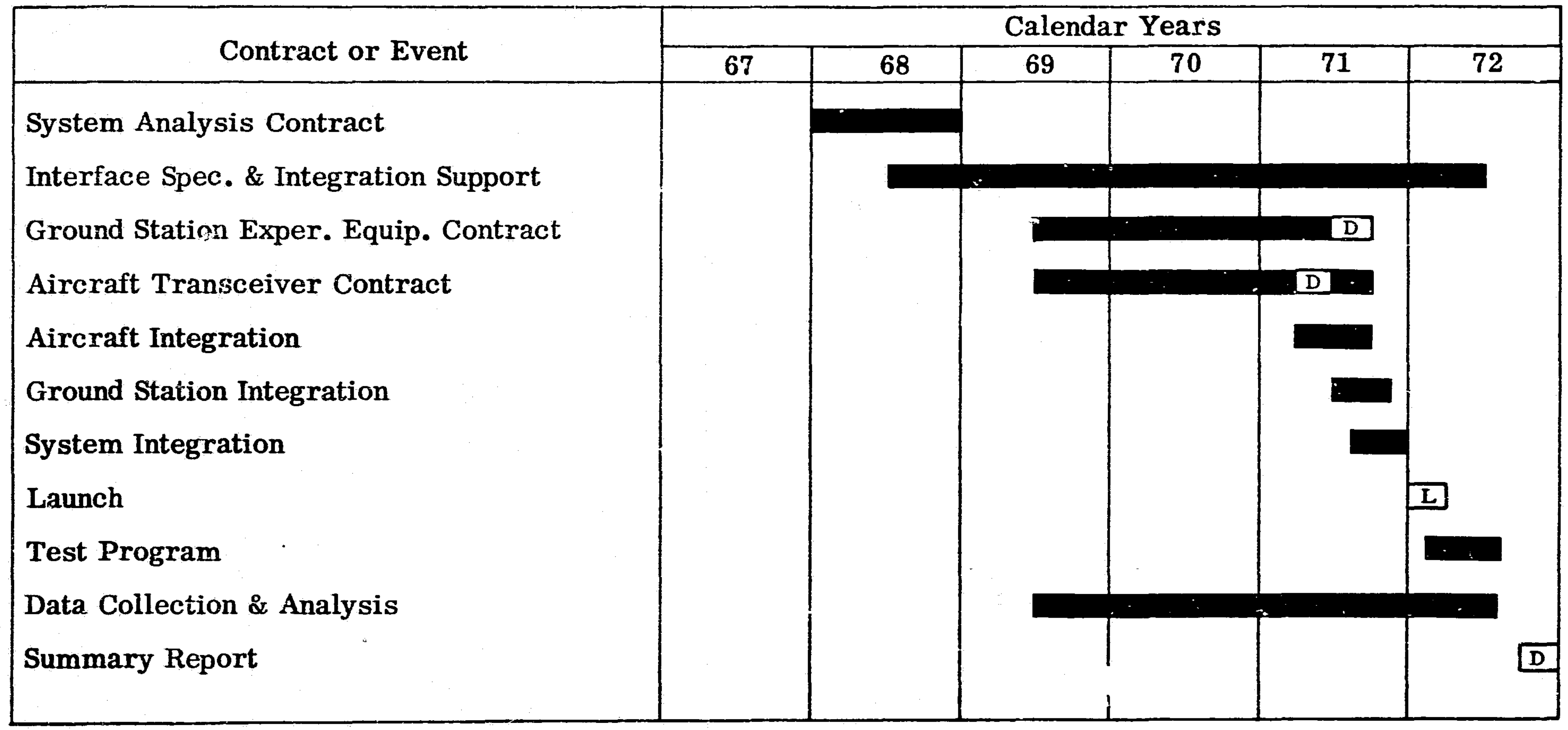
The Principal Investigator is Mr. Charles R. Laughlin, Assistant Branch Head of the Communications Research Branch. He is responsible for defining the overall goals of the experiment and assuring that the various equipments are technically capable of meeting these goals.

The co-investigator Mr. Roger Hollenbaugh, Systems Engineer in the Data Collection Systems Section. He is responsible for the Phase I and II systems study contracts and will be the technical officer on one or more hardware contracts. He will also be responsible for the Data Acquisition and Data Reduction efforts.

Mr. Walter K. Allen of the Data Collection Systems Section is the PLACE Project Manager. He is responsible for the overall implementation of the PLACE experiment, including contract management and coordinating the efforts of the various groups participating in the experiment.

The Tracking and Data Systems Directorate is responsible for the operation of the PLACE Control Center at GSFC and for supporting the deployment of the secondary ground stations. The T and DS Directorate is also supporting the data analysis requirements of the experiment. T and DS support for this experiment will be defined at a later date.

7. SCHEDULE


Contract or Event
Calendar Years
67
68
69
70
71
72
System Analysis Contract
Interface Spec. & Integration Support
Ground Station Exper. Equip. Contract
Aircraft Transceiver Contract
Aircraft Integration
Ground Station Integration
System Integration
Launch
Test Program
Data Collection & Analysis
Summary Report
D
D
L
D

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